Pumping

The brood stock RAS system is designed to run with a single centrifugal pump of 3 HP capacities. This pump draws the water from broodstock tank and sends the water to RSF, thereafter to protein skimmer, biological filter and finally back to broodstock tank. Thus, at a time the system is operated by a single motor, but to reduce the working load, two motors are used and these motors run alternatively with a 15 min gap. Together, both the motors run for 18 hours in a day by which 300% of the water gets circulated.

Performance of RAS system

Water quality parameters were continuously monitored for two years by keeping the fishes (orange spotted grouper and Indian pompano) at a stocking density of 1 kg/m^3 and feeding them at 5-6% of biomass daily. Water quality parameters were found to be optimum and it provided a conducive environment for achieving sex conversion and spawning of the fishes on par with the natural environment. Orange spotted grouper started spawning naturally after three months post introduction in to the tank. Fishes are spawning an average for 10-15 days in a month with 80% fertilisation rate. Indian pompano of 250g size attained sexual maturity at an average weight of 2.5 kg after 18 months of stocking. Fishes have been induced to spawn at intervals of two months and fertilised eggs have been produced continuously.

Spawning phenomenon in orange spotted grouper in RAS system

Economics

The high establishment cost associated with most RAS is due to the use of sophisticated filtration systems. In the present broodstock RAS designed, filtration mechanisms installed were modified to have synergistic impacts and all these system were operated by a combination of gravitational force and one motor. This is in contrary to most sophisticated RAS systems which use a number of motors (one for each filter). Added to cost, it creates difficulties, because if one motor fails it impacts the entire system. Hence, in the present system, water flow is designed by a combination of gravity and a single motor which eases the operation and drastically reduces the operational cost.

Parameters	Observed valus in RAS	Reference Value	Efficiency by reduction
TAN (ppm)	0.014 ±0.002	0.1	87.33 ± 6.43%
Ionised ammonia (ppm)	0.013 ± 0.002	-	87.33 ± 6.43%
Unionised ammonia (ppm)	0.001± 0.0001	0.05	87.33 ± 6.43%
Nitrite (ppm)	0.007 ± 0.001	1.0	81.66 ± 4.93 %
pH	7.90 ± 0.07	7.5-8.5	Improved
Alkalinity (ppm)	108.75 ± 3.48	80-120	Improved
Free carbon dioxide (ppm)	0.61 ± 0.24	<30	91.35 ± 5.46 %
Dissolved oxygen (ppm)	4.72 ± 0.08	>3	13.34 ± 2.46 %

Water quality parameters in RAS

Specifications	Quantity	Unit cost (Rs.)	Total (Rs.)
Capital Cost			
Electrical pump	2	21,000.00	42,000.00
Timer and Switch	2	2,000.00	4,000.00
Rapid Sand Filter	2	65,000.00	1,30,000.00
Protein Skimmer	2	35,000.00	70,000.00
Bio-filter tank	1	20,000.00	20,000.00
Molluscan shells	1 m^3	5,000.00	5,000.00
Bio balls	40000	8.00	32,000.00
Air blower	2	15,000.00	30,000.00
PVC pipe fitting etc			40,000.00
Miscellaneous			30,000.00
Grand total (RAS components excluding broodstock holding tank)			4,03,000.00
Broodstock tank (Concrete cement tank of 100 m^3 capacity)			10,00,000
Establishment cost			14,03,000.00
Running cost			
Electricity consumption per day: 36 kilowatt/ h			

Establishment and operational costs for the low cost broodstock RAS

Consultancy Services offered by CMFRI:

- RAS designing
- RAS construction and operation
- Human resource development in RAS

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LOW COST RECIRCULATING AQUACULTURE SYSTEM FOR MARINE FINFISH BROODSTOCK DEVELOPMENT

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Introduction

The major constrains in rapid expansion of aquaculture around the world are limitations for land and water availability, gradual deterioration of aquatic ecosystems, frequent disease outbreaks and difficulties with sediment and waste water treatment. One important and effective method of fish culture to solve these problems is the rearing of fish in Re-circulating Aquaculture Systems (RAS). RAS are indoor, tank-based systems in which fish are grown at high density under controlled environmental conditions to maximize fish growth year-round with effective disease control. These systems are used to maximize production where suitable land or water is limited, or where environmental conditions are not ideal for the particular species to be cultured. In this system water is mostly re-used after mechanical and biological treatment in an attempt to reduce the consumption of water and energy.

Broodstock development is the vital and time consuming procedure in marine finfish seed production. Generally the adult marine finfish are collected from wild and reared in captivity for developing matured broodstock. Presently, different culture systems like sea cages, cement/ fibre re-enforced plastic tank, earthen ponds with water flow through or water exchange and re-circulating system (RAS) are commonly used for marine finfish broodstock development. Among all, RAS system is gaining importance at present for marine finfish broodstock development for it's added advantages over use of the system. RAS reuse the water many times by passing the water through treatment processes to remove waste and to restore water quality. The system offers advantages that temperature and other water quality parameters can be controlled and provides conducive and static environment in order to maintain fish health in good conditions and also maximise the gonadal development of the fish.

Most RAS systems globally comprises of components like solids collecting systems (drum filter/sand filter), foam fractionation unit (protein skimmer), bio-filter, carbon dioxide degasser, nitrate filter, sterilisation point (usually UV sterilizer), temperature control, oxygen injection system and pH control and alkalinity dosing system. Most of these individual components in RAS is operated by individual pump, thus often it is necessary for several of these components to be combined for simplicity and capital savings. Added to this, running cost of the system should be minimum and stocked broodfishes should achieve early maturation and increased number of spawning frequencies. Keeping view of all the criteria, a low cost RAS was developed at Visakhapatnam Regional Centre of CMFRI, for brood stock development and spawning of cultivable marine finfishes.

Components of RAS

The RAS system was designed with the following components: broodstock maturation tank, Rapid Sand Filter (RSF), biological filter, protein skimmer, egg collection chamber and water pumping by electrical motor.

Broodstock maturation tank

The broodstock maturation tank is the major component in RAS, which holds all the broodstock fishes. The broodstock tank is made of Re-inforced Concrete Cement (RCC) and is 8m in dia with 2.5 m in depth and 125m^3 in volume. The tank is designed with the central drainage system to facilitate the complete removal of the waste along with water through centre. For collecting the floating eggs a hole is provided at 20 cm below from the top of the tank and through pipe the hole is connected to the egg collection chamber.


Circular broodstock maturation tank

Solid waste removal system

Management and removal of solids is one of the key processes in RAS. The main particulate waste matters in fish tanks are fecal matters, decaying uncollected spawned eggs, uneaten feed, decaying fish, and bio-film slough from tank and pipes. In the developed low cost RAS system, a Rapid Sand Filter (RSF) is fitted to remove the solid waste materials. RSF is designed to filter out the solid wastes larger than 3-40 µ with help of white sand filled in the RSF. The broodstock RAS established is fitted with 2 numbers of RSF, manufactured by Waterco Pvt Ltd. Maximum working pressure of the filter is 250 kPa, filled with 350 kg of white sand of 2 mm particle size. RSF is attached with multiport valve, and the main function of the valve includes filter, backwash, rinse and re-circulation. Depending on the need the valve position can be changed. RSF is back washed daily, for 15 minutes to clean the sand, by which around four tonnes of water is removed as waste and this needs to be compensated by adding the fresh sea water in the broodstock holding tank.


Rapid Sand Filter

Protein Skimmer

Foam fractionation or protein skimming is a technique used to remove surfactants (formed by protein degradation) from RAS water. The protein skimmers also stripes out fine solids and dissolved organic matters from the water. The protein skimmer used in the low cost broodstock RAS system is locally made using FRP material. It is conical in shape with a flat bottom and a head at the top surface with inlet at middle and outlet at bottom. A pipe provision for drawing atmospheric air is provided at the surface of the main unit, and this ventury pipe is conned to the inlet at the inside. The head of the skimmer is provided with a numbers of pores at the bottom, through which the protein waste formed from the main unit goes and then is removed through a single hole provided at the side of the head. During operation, water from RSF is pumped to the skimmer through inlet and the water mixes with the air and is churned, because of which foam is created and these foams are collected in the head and are then removed, thereafter cleaned skimmed water goes to the biological filter through the out-let.


Protein Skimmer

Biological filter

After the settleable and suspended materials have been removed by mechanical filtration, the next process is to remove the dissolved ammonia formed by waste excreted in the water and uneaten fish feed. Toxic ammonia is removed by the process of bio filtration by bacterial action by converting it to the relatively nontoxic nitrate (nitrification). In the brood stock RAS, the bio-filter tank (cement tank) of two ton capacity is filled with shells and bio-balls. The incoming waters from the RSF passes through the biofilm developed in the bio-balls & shells. Thereafter, the cleaned water is released through the outlet pipe at the bottom of the tank. Bio-balls of 4000 numbers and oyster shells of 1 m^3 are used for providing sufficient surface area for attachment of bacteria and for maximixing the contact with passing water for removal of all toxic ammonia.


View of biological filter in RAS


Biological Filter

Egg collection chamber

A triangular shaped cement tank of 0.5 m^3 water volume is used for egg collection. While collecting eggs the water in broodstock tank is re-circulated, which creates a circular motion, facilitating the movement of eggs along with water through the connecting pipe into the egg collection chamber. A hapa is tied in the egg collection chamber for collecting the eggs. In egg collection chamber, a mesh bag with mesh size of 500 µm is attached at the inlet pipes, by which the eggs that are bigger than this size are collected.


Egg collection chamber connected with broodstock tank